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(11) **EP 1 473 364 A1**

(12) **EUROPEAN PATENT APPLICATION**
published in accordance with Art. 158(3) EPC

(43) Date of publication:
03.11.2004 Bulletin 2004/45

(51) Int Cl.7: **C12N 15/11, C12Q 1/68**

(21) Application number: **02768095.8**

(86) International application number:
PCT/JP2002/009982

(22) Date of filing: **26.09.2002**

(87) International publication number:
WO 2003/068964 (21.08.2003 Gazette 2003/34)

(84) Designated Contracting States:
**AT BE BG CH CY CZ DE DK EE ES FI FR GB GR
IE IT LI LU MC NL PT SE SK TR**
Designated Extension States:
AL LT LV MK RO SI

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(30) Priority: **15.02.2002 JP 2002038930**

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(54) **METHOD OF TESTING FOOD**

(57) A method for detecting the presence/absence of a specific substance in foods by performing PCR using primers which are designed on the basis of data obtained from a part of a gene of the specific substance.

This method is highly useful in detecting a trace component contained in a food or identifying a specific harmful allergen.

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Description

Technical Field

5 [0001] The present invention relates to a food testing method, and more specifically to a method for detecting presence of a specified substance contained in a food in a trace amount over the entire distribution stage in order to indicate the presence/absence of an allergic substance in the food.

Background Art

10 [0002] Recently, to prevent health hazard attributed to foods containing allergic substances, requests for information service by indication thereof have increased. The indication of foods containing allergic substances has been made obligatory with enforcement of amendments to the Statutes on the Food Sanitation Law in April, 2001. In particular, with respect to five items (specified raw materials) of eggs, milk, and wheat which cause allergy most often, and buck-
 15 wheat and peanuts which cause serious symptoms, it has been made obligatory to perform proper indication over the entire distribution stage. There are individual differences as to what food people recognize as an allergen as the allergic substance. Thus, if a specified substance contained in the food is properly indicated even when the specified substance is contained in a trace amount, a person who ingests the food can know the presence/absence of the allergen contained in the food. However, it has been difficult to detect the presence/absence of a trace amount of a specified substance
 20 in a food having been heated or otherwise processed, by conventionally known methods for food analysis.

[0003] When a specified substance is used by a producer in his or her company, it is a matter of course that the specified substance can be indicated on processed foods. However, when a specified substance is used as an intermediate material of a final product, it is hard in some cases to confirm the presence/absence of the specified substance contained in a trace amount, particularly in a purchased intermediate material. Unintended inclusion may also actually
 25 occur.

[0004] For food manufacturers, it is important to precisely comprehend food additives such as processing aids and carry-over remaining in trace amounts or actual states of mutual contamination between manufacturing lines, and take proper measures as well as provide consumers with correct information based on the laws. Therefore, it has been desired to provide a technology of precisely analyzing allergic substances.

30 [0005] In Japan, buckwheat is a common food, but there are patients who exhibit an allergic response to the buckwheat. Many responses are of anaphylaxis type, and in the most serious case, the responses result in death. In the indication of foods containing allergic substances under the Food Sanitation Law, the buckwheat has been defined as one of the specified raw materials, and it has been made obligatory to indicate the presence of the buckwheat when the buckwheat is included in the food. But, there has been no appropriate method for measuring the amount of buck-
 35 wheat. Therefore, a reliable method for measuring a trace amount component has been desired.

[0006] Thus, it is an object of the invention to provide a method for measuring the presence/absence of a specified substance in a food based on the findings obtained from attempts to construct primers specific to buckwheat, to identify the detection limit thereof, and to apply the primers to processed foods for the purpose of developing a method for precisely analyzing the presence/absence of the buckwheat included in the food.
 40

Disclosure of the Invention

[0007]

45 [1] The present invention relates to a method for measuring presence/absence of a specified substance in a food, including: designing primers based on genetic information obtained from a part of genes of the specified substance; and performing PCR.

[2] Further, the present invention relates to a method for measuring presence/absence of a specified substance for indicating the presence/absence of a trace amount component in the food, including: designing primers based
 50 on information obtained from a part of genes of the specified substance; and performing PCR.

[3] The present invention also relates to a method for measuring presence/absence of a specified substance in a food, including: designing primers based on information obtained from a part of genes of the specified substance; and performing PCR to discriminate the food containing an allergen of the specified substance harmful for food
 55 ingesting person, a method for providing information as to whether the food contains a specified substance containing an allergen harmful for patients with food allergy or suspects thereof, or a method for indicating one of these about a food. The foods include not only foods for human beings but also foods (feedstuff) for animals.

[4] Here, the specified substance includes preferably specified cereals.

[5, 6] In addition, the food may be a processed food or a food raw material.

[7] The present invention provides the method in which the specified cereals include buckwheat.

[8] Here, it is preferable that the gene be a buckwheat gene shown in SEQ ID NO:11, and the primers be:

- (1) a sense primer and an anti-sense primer composed of at least 5 to 35 consecutive DNA fragments selected from information of a sequence from position 121 to position 360; or
- (2) a sense primer and an anti-sense primer composed of at least 5 to 35 consecutive DNA fragments selected from information of a sequence from position 1,381 to position 1,680.

The primers are complementary chains of a target gene, and sequence portions of N-terminus and C-terminus of the target gene are selected as a pair. Lengths in the pair may be the same or different.

[9] In particular, primer pairs of FAG 3 (SEQ ID NO:1)/FAG 4 (SEQ ID NO:2), FAG 17 (SEQ ID NO:5)/FAG 18 (SEQ ID NO:6), FAG 19 (SEQ ID NO:7)/FAG 20 (SEQ ID NO:8), FAG 19 (SEQ ID NO:7)/FAG 22 (SEQ ID NO:9), and FAG 19 (SEQ ID NO:7)/FAG 24 (SEQ ID NO:10) shown in Table 1 are preferable.

It is known that if PCR primers used for PCR are used for amplifying substantially in the same region of template DNA (in the case of buckwheat, the sequence of SEQ ID NO:11 is illustrated), they have the same function and produce the same result (PCR product). In the case of wheat, for example the individual primer sequence has the same function even if it is shifted by several to over 10 nucleotides on the corresponding same template DNA sequence toward 5'-upstream side or 3'-downstream side.

Therefore, the preferable primer pairs are not limited to those in Table 1, and those which can substantially accomplish the same functions as those of the above primer pairs in Table 1 are also included in the preferable primer pairs.

For the above primers, the primer where one or several nucleotides are deleted, substituted, added, and/or inserted and which hybridizes to the corresponding region of the template DNA is substantially the same as the above primers. The preferable primers in the present invention for example, include the primers having sequence shifted by one to several nucleotides or over 10 nucleotides toward 5'-upstream/downstream side and/or 3'-upstream/downstream side on the corresponding template DNA sequence complementary to the sequence of the primers of SEQ ID NOS:1 to 10. The preferable primers also include at least 80%, more preferably 90% or more, and still more preferably 95% or more of consecutive sequence in SEQ ID NOS:1 to 10.

[10] Further, there is provided the method, in which a clear amplified band is given in Polygonaceae Fagopyrum analytes including tatar buckwheat (*Fagopyrum tataricum*) and/or buckwheat (*Fagopyrum esculentum*) (not including wild buckwheat) but is not given in analytes including Polygonaceae analytes excluding Fagopyrum (tatar buckwheat and/or buckwheat) but including wild buckwheat (*Fallopia*), and animal and plant materials (including food raw materials derived therefrom) except buckwheat on an electrophoresis of the analyte subjected to a gene amplification reaction using the primers.

[11] There are provided PCR primers which are designed based on information obtained from a part of genes of a specified substance, and a set of reagents (kit) containing the same for measuring presence/absence and/or a concentration of the specified substance in a food.

Brief Description of the Drawings

[0008]

FIG. 1a is an electrophorogram (electrophoretic pattern) showing the specificity of buckwheat detection primers; FAG 19/22 to buckwheat. FIG. 1b shows the specificity of FAG 5/FAG 6.

FIG. 2 is an electrophorogram showing detection limit of a buckwheat detection system using PCR. FIG. 2a shows measurement of artificially mixed samples of DNA level, and FIG 2b is an electrophorogram showing measurement of artificially mixed samples of powder level.

FIG. 3 is an electrophorogram showing results of detection of buckwheat in processed foods by PCR. The kinds of the processed foods measured in FIGS 3a and 3b are different from one lane to another.

Best Mode for carrying out the Invention

[0009] The invention is more specifically illustrated.

[0010] The invention is a method for measuring the presence/absence of a specified substance in foods, comprising designing primers based on information obtained from a part of a gene of the specified substance and performing PCR.

[0011] The foods measured as subjects may be raw materials, materials in any step of processing, or foods after the processing. The method of the invention can detect the presence/absence of a specified substance in a trace amount of preferably 0.1% or less, 100 ppm or less, further 50 ppm or less, and 10 ppm or less, for example, in terms

of volume ratio of DNA in food or weight ratio of the specified substance to the whole food. With this method, if a gene of a specified substance is contained in a food, the presence/absence of the specified substance can be detected even when a substance which is not intended by a producer is present in a trace amount as a part of seasoning or an additive. DNAs are relatively stable by food processing such as heating compared to other substances derived from organisms

such as proteins, and the presence in a trace amount can be detected in a food heated, cooked or otherwise processed. [0012] A nucleotide sequence of the gene of the specified substance may be determined by any known methods when the sequence is unknown, but nowadays numerous known gene information can be used. For example, the information of the whole gene sequence of the specified substance is obtained from the database at National Institute of Genetics (DDBJ) and the like, and a pair (set) of a sense primer and an anti-sense primer suitable for PCR (Polymerase chain reaction) can be selected and designed based on the information on a part of the sequence to obtain the primers (probes).

[0013] In the design of the primers, attention was paid to the following items considering the testing method of the invention. (i) A GC content in a primer is from 40 to 60%; (2) A melting temperature (T_m value, see below) of a primer is from 55°C to 70°C; (iii) T_m values of two primers in the pair are close to each other; (iv) Two primers have no complementary sequences at 3' terminus; (v) The primer itself forms no high order structure such as hairpin; (vi) A full length of the primer is 15- to 35-mers; (vii) A GC content at 3' terminus of the primer is reduced; (viii) A sequence where the same nucleotide is consecutive in large numbers in the primer is avoided; (ix) The sequence of the primer is not necessary to be completely complementarily identical to that of the template DNA but complementarity at 3' terminus is increased; (x) There is no sequence complementarily identical to that of the primer in a DNA sample used.

[0014] The primers of the invention are required to be usable for not only buckwheat as a raw material but also foods during and after the processing such as heating and cooking. Further, it is considered that the template DNA of buckwheat is not intact but is fragmented. (xi) A region of the gene amplified by the two primers is a relatively short region. Moreover, it is necessary to design primers which fulfill all of the conditions of (i) to (xi) in one region of a gene that is commonly conserved in various species of buckwheat. However, it is very difficult to prepare primers which fulfill all of those conditions from DNA sequence composed of only four nucleotides, A, C, G, and T. Therefore, the design of the primers is a quite difficult problem when PCR is performed. Also, even if the primer that fulfills those many conditions can be designed, that is only a necessary condition for performing PCR. It is unknown whether the intended PCR is successful unless the PCR is actually performed.

[0015] A PCR method is not particularly limited and includes various known improved methods. In one example, a pair of primers and a template (analyte) DNA are mixed with reagents such as Tris-HCl, KCl, MgCl₂, dNTPs, and Taq DNA polymerase to give a reaction solution for the PCR. One cycle of the PCR is composed of three steps: heat denaturation, annealing of the primers, and a DNA synthetic reaction by DNA polymerase. The respective steps require different or, in some cases the same reaction temperatures and times, and thus, proper ranges are determined depending on the nucleotide sequence and length of the DNA region to be amplified. A thermal cycler is commercially available for such manipulations. The following formula obtained from the GC content and the length of the sequence:

$$T_m (^{\circ}\text{C}) = 4 \times (\text{G} + \text{C}) + 2 \times (\text{A} + \text{T})$$

is an indicator of the annealing temperature. The size of PCR product is adjusted to 50 - 500 bp, preferably about 100 - 150 bp. Within this range, DNA fragmented in the processed food can be detected.

[0016] When specified cereals include buckwheat, the above gene is a buckwheat gene shown in SEQ ID NO:11. The above primer is preferably (1) a sense or anti-sense primer which is composed of at least 5 to 35 consecutive DNA fragments selected from the sequence from position 121 to position 360 shown in SEQ ID NO:11; or (2) a sense or anti-sense primer which is composed of at least 5 to 35 consecutive DNA fragments selected from the sequence from position 1,381 to position 1,680. The primers are complementary chains of the target gene, and portions of N-terminus and C-terminus of the target gene are selected. Each length in the pair may be the same or different.

[0017] In particular, primer pairs of FAG 3 (SEQ ID NO:1)/FAG 4 (SEQ ID NO:2), FAG 17 (SEQ ID NO:5)/FAG 18 (SEQ ID NO:6), FAG 19 (SEQ ID NO:7)/FAG 20 (SEQ ID NO:8), FAG 19 (SEQ ID NO:7)/FAG 22 (SEQ ID NO:9), and FAG 19 (SEQ ID NO:7)/FAG 24 (SEQ ID NO:10) in Table 1 below or primer pairs which are substantially identical thereto are preferable. As described later in comparative example, even the primer pair of FAG 5 (SEQ ID NO:3)/FAG 6 (SEQ ID NO:4) which have the same T_m value is often unsuitable for the detection, and thus the selection of primers is important.

Table 1

[0018] NameSEQ ID NOSequence T_m GC%Position of primerSTARTENDsense FAG 315' CCA GCA ATT CCA GCA TCA GTG 3'6452149169anti-sense FAG 425' TTG GAG TAG GAA GGA AGC AAG A 3'6445334313sense FAG 535'

TGT CGC CGT CCG TGT CGT AA 3'6460278297anti-sense FAG 645' GGA TTC TTC GCT CTC ACT CTG
 3'6452530510sense FAG 1755' TGG AGT GGG TGG AGT TGA AGA 3'64521,4351,455anti-sense FAG 1865' TCA
 TCT CGG GAC TGG AAT GGT 3'64521,6241,604sense FAG 1975' AAC GCC ATA ACC AGC CCG ATT
 3'64521,4641,484anti-sense FAG 2085' TCT CAT CTC GGG ACT GGA AGT 3'64521,6261,606sense FAG 1975' AAC
 5 GCC ATA ACC AGC CCG ATT 3'64521,4641,484anti-sense FAG 2295' CCT CCT GCC TCC CAT TCT TC
 3'64601,5901,571sense FAG 1975' AAC GCC ATA ACC AGC CCG ATT 3'64521,4641,484anti-sense FAG 24105'
 AAC CTC CTG CCT CCC ATT CTT 3'64521,5921,572

[0019] When suitable PCR conditions such as concentrations of Taq DNA polymerase and MgCl₂, and the reaction cycle number are examined or nested PCR is used, there is a possibility that detection sensitivity is further increased.

10 [0020] A PCR product may be identified using an immune reaction or by any other method. When a clear band is observed on an electrophorogram obtained by performing electrophoresis using positive and negative controls if necessary, the presence of a test substance in an analyte can be confirmed.

[0021] The method of the invention can be easily conducted by using a set of reagents (kit) containing the primers designed based on the information obtained from a part of the gene of the specified substance. The set of the reagents
 15 (kit) may contain known reagents conventionally used for PCR, or may be equipped with another apparatus such as an electrophoresis apparatus. The reagents include dNTPs, MgCl₂, Taq polymerase, Tris-HCl, glycerol, DMSO, DNA for positive control, DNA for negative control, and distilled water. Those reagents in the kit may be provided in an individually packed state or in a form where two or more reagents are mixed with each other. Concentrations of respective reagents in the kit are not particularly limited, and may be in the ranges suitable for the PCR of the invention.
 20 Also, the kit may include information on suitable PCR conditions or the like, or may be only composed of the primer reagents.

[0022] In the method of the invention, the substances to be detected are not limited so long as they are foods. To take cereals as an example, the test substances include wheat, rice, maize, foxtail millet, millet, Japanese millet, buckwheat, and beans. DNAs are stable to heat and can be detected in trace amounts in processed foods. Therefore, the
 25 obtained result can be utilized for indication on foods or as information on food allergies. In addition, by detecting the specified cereals in the food, it is possible to detect a trace amount of a specified substance remaining in food additives such as processing aids and carry-over or inclusion which is not intended by a producer such as mutual contamination between manufacturing lines.

[0023] Hereinafter, the present invention is concretely illustrated using buckwheat as an example, but the invention
 30 is not limited thereto.

(1) Construction of primers for detection of buckwheat

[0024] Before constructing primers for the detection of DNA derived from buckwheat, the inventors accessed the
 35 database in the National Institute of Genetics (DDBJ), searched for known genes of buckwheat (*Fagopyrum esculentum*), and selected *Fagopyrum esculentum* major allergenic storage protein gene (Accession #AF152003, full length: 1,825 bps) from genetic information concerning buckwheat. Next, it was confirmed by the BLAST search in DDBJ that there is no similar sequence to the sequence of the selected buckwheat gene in plants other than the buckwheat.

[0025] In order to design the primer, the inventors searched for sequences which are candidates of the primers for
 40 a gene sequence of a specified substance using software "GENETYX MAC". GENETYX MAC used can set up various conditions for primer design, e.g., (i) GC content and (ii) range of T_m value which were difficult to determine by manual calculation. As a result, 67 pairs of the candidate primers were found. The inventors have uniquely searched for the sequences which fulfill all of the above conditions (i) to (xi) for the primer design and found primer sequences usable
 45 in the testing method of the invention. Nine pairs of oligonucleotide primers (synthesized by Biologica Co.) including the thus found primer sequences were prepared.

(2) Extraction of DNA

[0026] Surfaces of seeds of buckwheat and other plants were washed with 1% Triton X (Wako Pure Chemical Industries Ltd.), rinsed with distilled water, dried well, and then the seeds were finely ground with Multi Bead Shocker
 50 (Yasui Kikai Co., Ltd.). Next, DNA was extracted from 1 to 1.5 g of a ground sample using Dneasy Plant Maxi kit (Qiagen). For processed foods, those whose water content was high were lyophilized for 24 hours, and those whose water content was low were directly used. Then, DNA was extracted from 1 g of each by using Genomic Tip 20/G (Qiagen). The concentration of the extracted DNA was determined by measuring the absorbance, and subsequently
 55 the DNA was diluted with purified water to 10 ng/μl and was used as a template (test) DNA sample of PCR.

(3) Detection of buckwheat by PCR and electrophorogram

[0027] A reaction solution of PCR was prepared as follows. 2.5 µl of a DNA sample solution adjusted to 10 ng/µl was added to a solution containing PCR buffer (PCR buffer II, Applied Biosystems), 200 µmol/L of dNTP, 1.5 mmol/L of MgCl₂, 0.5 µmol/L of sense and anti-sense primers, and 0.625 unit of Taq DNA polymerase (AmpliTaq, Gold, Applied Biosystems) to obtain a total volume of 25 µl. Those with no description of a template DNA amount in Table 3 have this concentration. But, when the concentration of the extracted DNA was 10 ng/µl or less, when the absorbance OD₂₆₀/OD₂₈₀ of the DNA obtained from processed foods or the like containing many additives was 1.7 or less, the DNA was containing many impurities. When the purity of the DNA was low, 2.5 µl to 17.8 µl of the undiluted DNA solution or 10 ng/µl diluted solution was added to the PCR reaction solution, and the total volume was adjusted to 25 µl with purified water. Those with the description of the template DNA amount in Table 3 have this concentration.

[0028] GeneAmp PCR System 9600 (Applied Biosystems) was used as a PCR amplification apparatus, and reaction conditions were set as follows. First, the temperature was retained at 95°C for 10 min, and the reaction was started. Next, 95°C for 30 sec, 60°C for 30 sec, and 72°C for 30 sec were set as one cycle, and 40 cycles of PCR were performed. Finally, a termination reaction at 72°C for 7 min was conducted, and subsequently the solution was stored at 4°C to give a PCR product solution.

[0029] The PCR product solution was subjected to electrophoresis using 2% agarose gel (2% E-Gel, Invitrogen) containing ethidium bromide. Validity of the PCR was determined by the presence/absence of an amplified band from a positive control (DNA extracted from the buckwheat flour) and a negative control (blank reaction solution without template DNA). Then, the presence/absence of buckwheat in the sample was determined by identifying a DNA amplified band with optimal size produced by each set of primers.

(4) Experiment 1. Confirmation of specificity of primers for buckwheat detection

[0030] For the purpose of selecting primers for specific detection of the buckwheat, PCR was performed using DNAs extracted from seeds of buckwheat and other plants. As samples of the buckwheat, 7 species of buckwheat seeds [Mancan (US, Canada, China), Nei Mongol (China), Yurin (China), Kitawase (Hokkaido), Aizu Domestic (Fukushima)] and two species of buckwheat flours A and B for business use were used. Also, the seeds of two species of wheat (Norin 61, Canadian Amber Durum), rye (Canada), barley (Minorimugi), rice (Koshihikari), maize (non GMO for feedstuff), soybean (Murayutaka), foxtail millet (Kumamoto), rapeseed (Canola), oat or oats (feedstuff for racehorse) and wild buckwheat (obtained from Research Institute for Bioresources, Okayama University) were used as the other plants.

[0031] After the PCR, electrophoresis was performed, and primers which afforded a clear amplified band with optimal size only in the buckwheat samples but not in the other samples were selected as the primers which can specifically detect the buckwheat.

[0032] FIG. 1a is an electrophorogram showing the specificity of the primers for buckwheat detection; FAG 19/22. In FIG. 1a, M represents 100 bp ladder marker and NC represents no template control (blank without template DNA). Table 2 below shows lane numbers (sample names) in FIG. 1a and the results thereof.

[0033] FIG. 1b is an electrophorogram showing the specificity of the primers : FAG 5/FAG 6 shown in Table 1. In FIG 1b, a lane number 1: Mancan species (Canada), 2: Nei Mongol species (China), 3: Yurin species (China), 4: Aizu domestic species (Japan), 5: buckwheat flour A for business use, and M: 100 bp ladder marker. In FIG. 1b, non-specific bands appeared, which shows that the primers are not suitable as the primers for buckwheat detection.

Table 2. Specificity of primers for buckwheat detection; FAG 19/22

Sample name	Cultivar	Production area	Detection result by PCR	Lane number in FIG. 1
Buckwheat seeds	Mancan	US	+	1
Buckwheat seeds	Mancan	Canada	+	2
Buckwheat seeds	Mancan	China	+	3
Buckwheat seeds	Nei Mongol	China	+	4
Buckwheat seeds	Yurin	China	+	5
Buckwheat seeds	Kitawase	Hokkaido	+	6
Buckwheat seeds	Aizu domestic	Fukushima	+	7
Buckwheat flour	A		+	8
Buckwheat flour	B		+	9
Wheat	Norin 61	Japan	-	10
Wheat	(Durum)	CAD (Canadian Amber Durum)	-	11
Rye		Canada	-	12
Barley	Minorimugi	Japan	-	13
Rice	Koshihikari	Japan	-	14
Maize	non GMO (feedstuff)	Australia	-	15
Soybean	Murayutaka	Japan	-	16
Foxtail millet		Kumamoto	-	17
Rapeseed		Canada	-	18
Oat		Feedstuff for racehorse	-	19
Wild buckwheat		Obtained from Research Institute for Bioresources, Okayama University	-	20

As a result of the experiment 1, a set of FAG 19/22 (amplified size: 127 bps) was selected as the primers in the following experiment.

FAG 19 (sense primer): 5'-AAC GCC ATA ACC AGC CCG ATT-3'

FAG 22 (anti-sense primer): 5'-CCT CCT GCC TCC CAT TCT TC-3'

[0034] Among the plants except the buckwheat, the wild buckwheat belongs to the same Polygonaceae family as the buckwheat, but this primer set exhibited no cross reaction in the wild buckwheat sample (FIG. 1a, Table 2).

(5) Experiment 2. Identification of detection limit of buckwheat by PCR

[0035] In the experiment 2, for the purpose of examining the detection limit of buckwheat by PCR using FAG 19/22 primers, artificially mixed samples of buckwheat were prepared at DNA level and powder level, and PCR was performed using solutions of the samples to identify the detection limit of buckwheat.

[0036] The artificially mixed samples at the DNA level were prepared by: diluting DNAs extracted from the seeds of wheat and buckwheat to 10 ng/μl, respectively; and mixing wheat DNA and buckwheat DNA so that the ratios of the buckwheat DNA to the wheat DNA were 0.1 ppm, 10 ppm, 50 ppm, 100 ppm, 1,000 ppm and 1% by volume. Alternatively, the artificially mixed samples at the powder level were prepared by mixing wheat flour and buckwheat flour so that the mixed ratios of buckwheat flour to wheat flour were 0.1 ppm, 10 ppm, 50 ppm, 100 ppm, 1,000 ppm, and 1% by weight. Subsequently, each mixed sample was finely ground, and then DNA was extracted.

[0037] FIGS 2a and 2b are electrophorograms showing results of the detection. Upper numerals indicate the content of buckwheat, and M represents 100 bp ladder and NC represents no template control (blank without template DNA). In FIG. 2a, the samples at the DNA level prepared by diluting the buckwheat DNA with the wheat DNA were used for the analyte. In FIG. 2b, the samples at the powder level prepared by diluting the buckwheat flour with the wheat flour were used for the analyte.

[0038] In the experiment 2, the detection limit of buckwheat by PCR using FAG 19/22 was identified. Results show that the detection limit of buckwheat in both the samples at the DNA and powder levels was 10 ppm (FIG. 2). In the experiments repeated multiple times, however, the detection limit was 50 ppm in several experiments, and thus, it has been suggested that the limit stably detectable by this PCR is 50 ppm. A food allergy sometimes occurs in certain people by a trace amount of an allergic substance. Therefore, the food containing a designated raw material must be indicated even in a trace amount regardless of its amount according to "obligation to indicate the foods containing allergic substances" with the enforcement of amendments of the Food Sanitation Law. Criteria by which necessity of the indication is determined are given in the interim report (October 17, 2001) in the Conference on Allergy Indication in the Ministry of Health, Labour and Welfare, and it is reported that the indication is necessary when a specified raw material is contained in a processed food in an amount of several μg/ml (g) or more (1 to 9 ppm or more) in terms of total protein amount. The protein content in whole buckwheat flour is about 12% by weight (according to the Food Composition Table, 5th edition), and thus, 50 ppm of the detection limit by the PCR corresponds to 6 ppm of the mixing ratio of the buckwheat protein. Accordingly, it is expected that the method for detecting the buckwheat by the PCR as mentioned above is an analytical method sufficiently suitable to detect the indication criteria presented by the Conference on Indication.

(6) Experiment 3. Detection of buckwheat in processed foods by PCR

[0039] The detection of buckwheat was performed from processed foods containing buckwheat as a raw material using FAG 19/22 as the primers. Samples used were two kinds of dried noodles (100 percent buckwheat noodle, 30 percent buckwheat noodle), four kinds of confectionery (buckwheat cakes A and B, fried buckwheat dough cake, buckwheat cookie, baked goods), and buckwheat tea. The samples were each finely ground. Subsequently, DNAs were extracted from the dried noodles using Dneasy Plant Maxi kit (Qiagen), and from the confectionery and the tea using Genomic Tip 20/G (Qiagen) and the extracted DNAs were subjected to the PCR. Since the DNA purity obtained from the buckwheat cake B was as low as 1.2, 50 to 1,800 ng of the DNA (as calculated from the absorbance) per tube was used for the PCR reaction.

[0040] Table 3 shows lane numbers (sample names) in FIGS 3a and 3b.

Table 3

Lane number	Sample name
1	Buckwheat cake A
2	Buckwheat cake B (template DNA: 50 ng/tube)
3	Buckwheat cake B (template DNA: 120 ng/tube)
4	Fried buckwheat dough cake
5	Buckwheat cookie
6	Baked buckwheat goods
7	Buckwheat tea
8	Buckwheat seeds
9	Water
10	100 bp ladder

[0041] FAG 19/22 were used in the processed foods for the detection of buckwheat (Experiment 3). As a result, except the buckwheat cake B, the buckwheat was detected in the defined template DNA amount of 25 ng per PCR (FIG. 3a). On the other hand, in the buckwheat cake B, even when the template DNA was further added to increase the amount to 50 ng or 120 ng, no PCR amplified band was observed, but when the template DNA amount was increased to 1,800 ng, the detection of buckwheat became possible (FIG. 3b).

[0042] Food allergy tests currently carried out in the clinical settings include provocative test, skin prick test and RAST method. However, the targets in the tests by these methods are patients suffering from allergies or blood thereof and it is difficult to apply these methods to food analysis. On the other hand, electrophoresis (SDS-PAGE), western blotting, and immunochemical methods (ELISA) have been used for isolating and detecting a specific protein for the

purpose of detecting and quantifying an allergen per se and these methods are effective for the detection of known major allergens. However, these methods are not necessarily appropriate for the detection of unknown allergens or in processed foods in which proteins may be potentially denatured by heating.

5 Industrial Applicability

[0043] DNAs very often remain in processed foods because of their higher heating resistance than proteins. Therefore, the method for detecting a specified substance based on a PCR method according to the present invention is significantly useful particularly in processed foods as a means for indirectly analyzing a substance causative of an
10 allergy in a food, which compensates for conventional protein detection methods.

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SEQUENCE LISTING

5

<110> H . YAMAKAWA et. al.

10

<120> Method of food analysis

15

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<221> CDS

<222> (39)..(1655)

<223> major allergenic storage protein (FAGAG1) mRNA, complete cds.

<400> 11

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	ccctctcact gtgccctatg glactaagct gcctctgcga gclatlgcca lggcagaagg	120
20	gacaacgcag ccgccccac calggacacc agcaallcca gcalcagigt galatccaga	180
	ggctcaccgc clclgagccc lcclgtagag lccgglicga ggccggagtl acigagatll	240
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	agcclggagg cccltltgtt cctlccclact ccaacgcccc tlacalcacc tlgtctgagc	360
30	aaggaggagg aglgcaggga glggltcgtc caggatgccc ggagacgtlc cagtcagggt	420
	cggaalllga glaccctcgg lclcagagag accaacgtlc caggcagagt gagagcggag	480
35	aalccagccg lggagaccaa cgtlccaggc agaglgagag cgaagaalcc agccglggag	540
	accaacgtlc caggcagagt gagagcgaag aalccagccg lggagaccag caccagaaga	600
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45	accagctcga lgagaacgtl aggaactlcl lcltagclgg lcagagcaag cagagcaggg	780
	aggaccgccc cagccagcga cagactaggg aggaaggcag lgaccgcca lcccgigaga	840
50	gccaagacga cgaagcactl clcgaagcaa acatcllgag lggatlcgag gacgagalcc	900
	lccaagaaal clccgaaal gltgaccagg agaccalcag caagclcaga gglgagaacg	960
55	accagagagg alcatcgtc caggclcggt acclcaaact ccgggtccca gaggaglatg	1020

5 aagaagaac1 ccagagggaa agagg1gaca ggaaaagagg lggaagcggg aggagcaatg 1080
 gal1ggagca agcg11c1gc aacc1gaaat 1caggcaaaa 1g11aacagg cc11c1cgcg 1140
 10 ccgacg1c11 caaccacgc gccgg1c1a 1caacaccg1 agacagcaac aat1c1ccga 1200
 1c1c1gaat1 catccaac11 agcgcccagc acg1c1c1c1 clacaagaat gcgatcc1cg 1260
 gaccgagatg gaact1gaac gcgcacagcg cac1g1acg1 gacgagagga gaaggaagag 1320
 15 1ccaggt1gt cggagatgaa ggaagaag1g 1g11cgacga caacg1gcag cgaggacaga 1380
 1c11t1gtgt cccacaggga 11cg1cag1gg 1gt1gaaggc aggaagagaa ggac1ggagt 1440
 20 ggg1ggagt1 gaagaacgac gacaacgcca 1aaccagccc gal1gccggg aagact1cgg 1500
 1gt1gagggc gatccc1g1g gaggt1c11g ccaac1c1a cgata1c1cg acgaaggaag 1560
 25 cg11cagat1 gaagaatggg aggcaggagg 11gagg1c11 ccgaccat1c cag1ccc1gag 1620
 1gagaagga gagggagcgt 11c1ccatag 111aagagag acaaagggtc 1atcg1atgc 1680
 30 aaa1aaaac agaaggagaa ggataaggga g1c11g1c1a 1cg111agct ag1caagtcc 1740
 35 c1c11ccac1 1c1gggt1at g11c1atgt1 111ac111ag 1g1caataaa agagt1gaat1 1800
 c1cgaaaaaa aaaaaaaaaa aaaaa 1825

Claims

- 45 1. A method for measuring presence/absence of a specified substance in a food, comprising: designing primers based on information obtained from a part of genes of the specified substance; and performing PCR.
 2. A method for measuring presence/absence of a specified substance for indicating the presence/absence of a trace amount component in the food, comprising: designing primers based on information obtained from a part of genes
 50 of a specified substance; and performing PCR.
 3. A method for measuring presence/absence of a specified substance in a food, comprising: designing primers based on information obtained from a part of genes of the specified substance; and performing a gene amplification reaction PCR to discriminate the food containing an allergen of the specified substance harmful for a food ingesting
 55 person.
 4. The method according to any one of claims 1 to 3, wherein the specified substance comprises specified cereals.

5. The method according to any one of claims 1 to 4, wherein the food comprises a processed food.
6. The method according to any one of claims 1 to 4, wherein the food comprises a food raw material.
7. The method according to any one of claims 1 to 6, wherein the specified cereals comprise buckwheat.
8. The method according to any one of claims 1 to 7, wherein the gene comprises a buckwheat gene shown in SEQ ID NO:11, and the primers comprise:
 - (1) a sense primer and an anti-sense primer composed of at least 5 to 35 consecutive DNA fragments selected from information of a sequence from position 121 to position 360; or
 - (2) a sense primer and an anti-sense primer composed of at least 5 to 35 consecutive DNA fragments selected from information of a sequence from position 1,381 to position 1,680.
9. The method according to any one of claims 1 to 8, wherein a clear amplified band is given in analytes including tatary buckwheat (*Fagopyrum tataricum*) and/or buckwheat (*Fagopyrum esculentum*) but is not afforded in analytes including wild buckwheat (*Fallopia*) on an electrophorogram after PCR is performed using the primers.
10. Primers for use in PCR for measuring presence/absence and/or a concentration of a specified substance in a food, which are designed based on information obtained from a part of genes of the specified substance.
11. A kit for measuring presence/absence and/or a concentration of a specified substance in a food, the kit comprising primers for PCR designed based on information obtained from a part of genes of the specified substance.

FIG. 1a

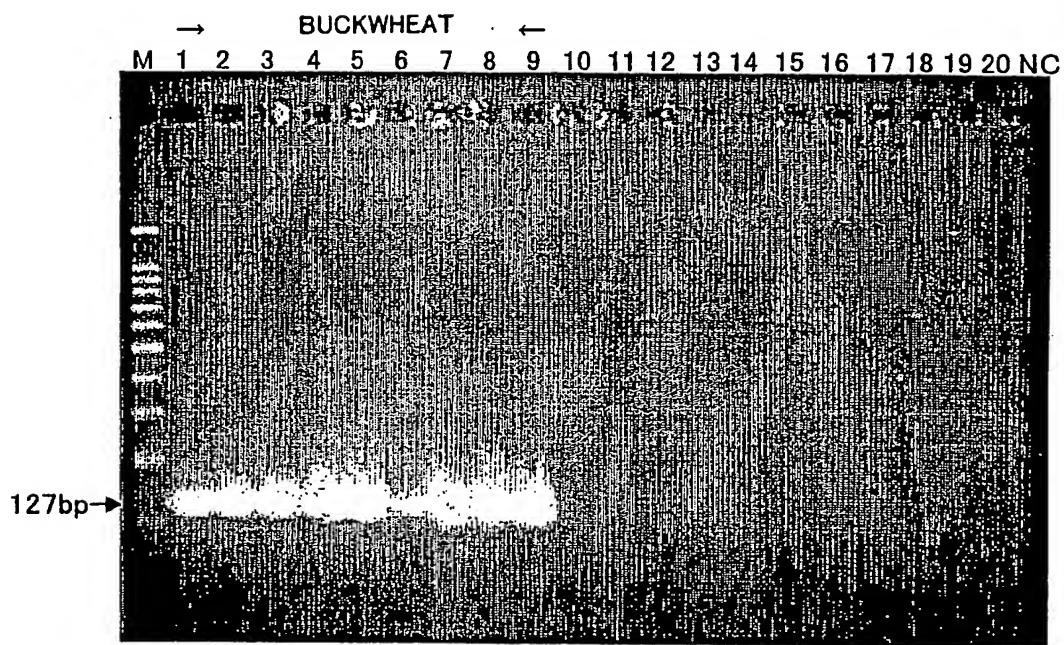


FIG. 1b

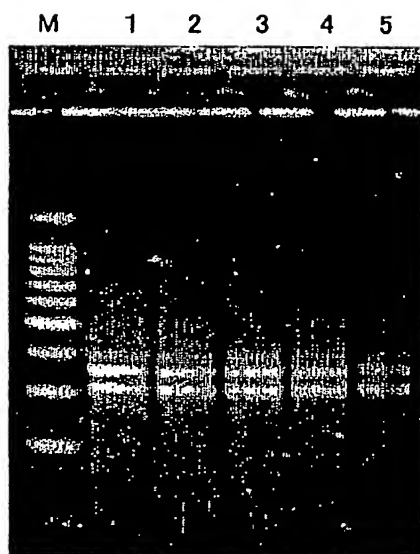


FIG. 2a

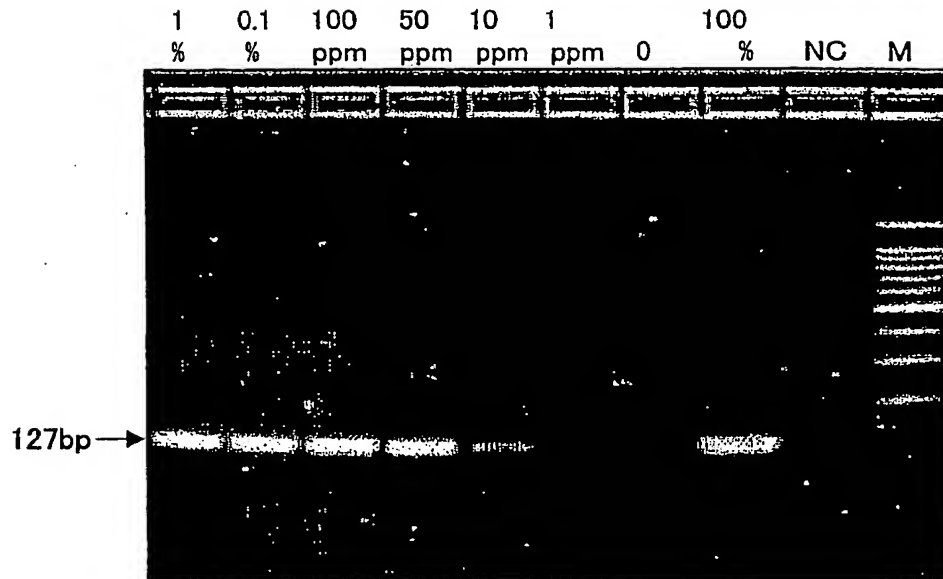


FIG. 2b

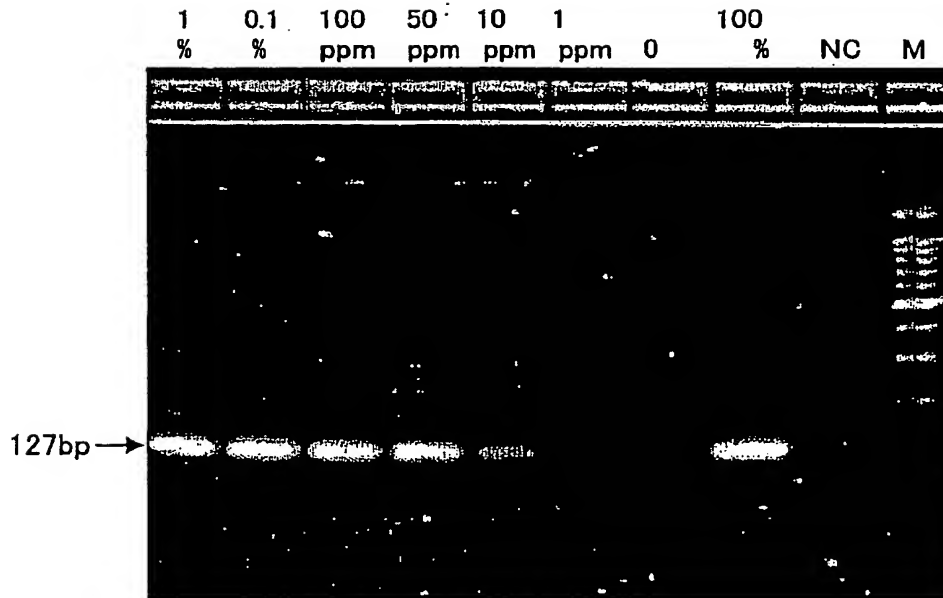


FIG. 3a

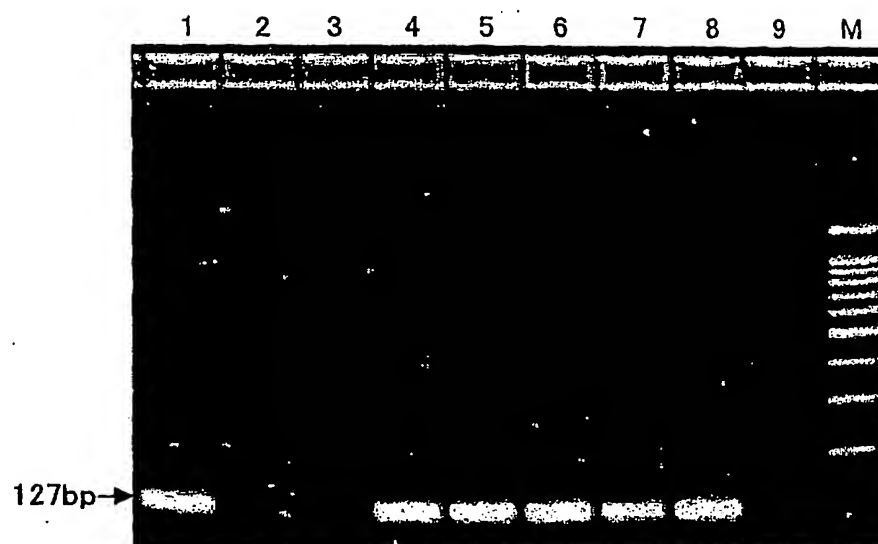
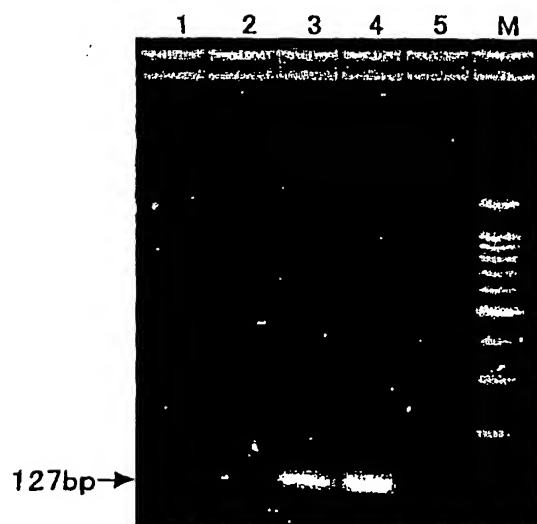


FIG. 3b



INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP02/09982

A. CLASSIFICATION OF SUBJECT MATTER Int.Cl ⁷ C12N15/11, C12Q1/68		
According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED Minimum documentation searched (classification system followed by classification symbols) Int.Cl ⁷ C12N15/00-15/90, C12Q1/68		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used) GenBank/EMBL/DDBJ/GeneSeq SwissProt/PIR/GeneSeq BIOSIS/WPI (DIALOG), JICST FILE (JOIS)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y .	JP 2001-309786 A (House Foods Corp.), 06 November, 2001 (06.11.01), (Family: none)	<u>1-6, 10-11</u> 7-9
Y A	NAIR A. et al. A molecular-genetic approach for hypoallergenic buckwheat. Fagopyrum, Vol.16(1999) pages 29 to 36	<u>7-9</u> 1-6, 10-11
Y A	Sukenobu FUJINO, "Soba Allergy no Genin o Saguru, Allergen Protein wa Dokomade Kaimei Saretaka?" Kagaku to Seibutsu, November 2001, Vol.39, No.11, pages 707 to 708	<u>7</u> 1-6, 8-11
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "E" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed		"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family
Date of the actual completion of the international search 22 November, 2002 (22.11.02)		Date of mailing of the international search report 10 December, 2002 (10.12.02)
Name and mailing address of the ISA/ Japanese Patent Office		Authorized officer
Facsimile No.		Telephone No.

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/JP02/09982

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	FUJINO K. et al. Expression, Cloning, and Immunological Analysis of Buckwheat (<i>Fagopyrum esculentum</i> Moench) Seed Storage Proteins. J.Agric.Food Chem., Vol.49, No.4 (2001) pages 1825 to 1829	1-11

Form PCT/ISA/210 (continuation of second sheet) (July 1998)